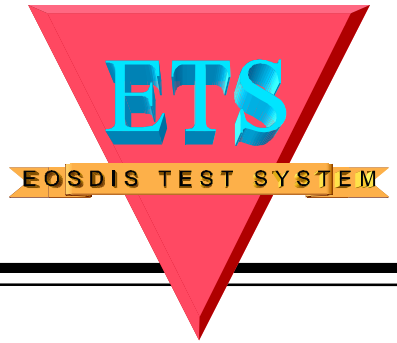


Earth Observing System
Data and Information System

EOSDIS Test System (ETS) for PM-1 Support

System Requirements and Design Review

September 17, 1998

Agenda

• Introduction	Willie Fuller
• Requirements Review	Estelle Noone
– MPS Delta Requirements	
– SCTGEN Delta Requirements	
• System Design	Ernest Quintin
– MPS Alternatives	Bill Parlock
– SCTGEN	
• Concluding Material	Estelle Noone
– Test Approach	
– Schedule	
– Needs List	

Introduction

Review Purpose

- Present our understanding of the delta requirements for ETS for PM-1 support and receive concurrence on the set of requirements
- Present alternative designs for the MPS for PM-1 and receive concurrence on the development approach

MPS High Level Capabilities

- Provides configuration control to the user
- Displays configuration and status to the user
- Uses the PM-1 project data base (PDB) to generate telemetry and verify commands
- Provides a limited telemetry response to valid spacecraft commands
- Provides user great flexibility in setting telemetry values
- Simulates the PM-1 spacecraft over a serial interface
  - Generate and transmit low-rate PM-1 spacecraft telemetry data as CADUs for input to EDOS
  - Receive and verify spacecraft commands in a CLTU bitstream from EDOS
  - Interface to EDOS using the protocols and formats specified in the Space to Ground ICD

MPS High Level Capabilities

- Simulates the spacecraft and EDOS to EOC interface
  - Generate and transmit low-rate PM-1 spacecraft telemetry data as packets in EDUs for input to the EOC
  - Receive and verify spacecraft commands in Command Data Blocks from the EOC
  - Interface to the EOC using the protocols and formats specified in the EDOS to EGS ICD

SCTGEN High Level Capabilities

- An offline utility that generates data for return link data streams based on user specification
- Generates CADUs, EDUs, RBFs, EDSs, and PDSs
- Provides comprehensive error insertion capabilities
- Provides for integration of user supplied data into data scenarios
- Runs on various UNIX-based platforms such as the HP, SUN and SGI computers

Lessons Learned from AM-1 Support

- Had there been more MPS units available, they would have been used
- Had the hardware replication costs been lower, there would have been more MPS units
- Had the MPS hardware been more compact and portable, the MPS probably would have been sent to ground stations for test support

Lessons Learned (Continued)

- MPS has proven to be a very useful and flexible test tool -- several of its best features evolved through users' requests
- MPS has enjoyed a wide user base, including SI&T, FOT, MOC developers, and instrument test team representatives
- Need to plan for periodic user training especially if users expected to continue to serve as operators
- MPS coexists very well with SSIM
- Until a common spacecraft architecture is adopted, then purely generic spacecraft simulators are only a goal -- tailoring still is required for mission-specific and user-requested features

Lessons Learned (Continued)

- Much more control is provided through the SCTGEN intermediate script than is supported by the GUI
- Working with the SCTGEN script is complex
- Error checking is limited

MPS Highlights

- MPS and its developers available prior to SSIM for early FOS testing and both played critical support role in leading up to first two successful ECTs
- MPS PDB translation utility and developer able to provide reports of anomalous data conditions in the PDBs to FOT
- MPS telemetry modeling feature used successfully for CERES procedure checkout
- MPS flexibility came in handy when non-standard spacecraft configurations needed, e.g.,
  - Playing Q-channel data on the I-channel
  - Transmitting data at non-AM-1 rates to check out FOS handling

SCTGEN Highlights

- SCTGEN used to create test data files to support EDOS Acceptance Testing and Y2K testing
- SCTGEN being used to create CADU test data to support 72-hour operational scenario for EDOS testing
- SCTGEN used extensively to support ECS science testing by simulating EDOS-formatted data sets
- SCTGEN capability of building data sets using user-provided instrument data and SCTGEN-generated construction records proved very useful for ECS testers

ETS Requirements Review

ETS Delta Requirements

- ETS Functional and Performance Requirements (level 3) and MPS and SCTGEN system requirement specifications (level 4's) subject of this review
- ETS F&PR Changes
  - Replaced AM-1 with PM-1
  - Replaced AM-1 data rates with PM-1 telemetry and command rates
  - Replaced DSN, GN, and WOTS with EPGS
  - Removed requirements for support of 4800-bit block data formats
  - Removed requirements for OMD simulation

MPS Delta Requirements

- Requirements removed from MPS
  - 4800-bit Nascom block support
  - OMDSIM
  - Kerberos FTP
  - CPU and platform specific
- Requirements added specifically for PM-1
  - Year 2000 ready (current MPS is compliant)
  - Convolutional encoding
  - Data randomization
  - Command echo

MPS Delta Requirements (Continued)

- Implied requirements added to reflect as-built system
  - Configure command receipt for EDOS mode
  - Configure telemetry for EDOS mode
  - Control telemetry and command logging
  - Control simulation timeline (scenario file) execution
  - Create and transmit signal file
- DRB-approved change requests requirements included
  - Select PDB version
  - Enable and disable transmission of CLCW EDUs
  - Select network configuration default addresses and ports

MPS Delta Requirements (Continued)

- Changed Requirements (* associated with PM-1)
  - GUI
    - » Display event messages and echo operator directives to the screen
    - » Log event messages and operator directives to a disk file
    - » Build configuration directives to set GMT time
    - » Build configuration directives to set packet generation rates
    - » Build directives to start and stop orbit modeling
    - » Display command packets received
  - Command related
    - » Respond in telemetry to spacecraft commands as defined in the End-Item Verifiers PDB file
    - » Respond to commands to set and adjust the spacecraft clock*
    - » Comply with command data formats and protocols as defined for the EPGS to EDOS interface*

MPS Delta Requirements (Continued)

- Telemetry related
  - » Execute directives to set packet generation rates*
  - » Display telemetry parameters in either raw data or engineering units
  - » Set initial values from information extracted from the PDB and from user provided files
  - » Generate and transmit telemetry packets with APIDs defined for the PM-1 spacecraft*
  - » Format telemetry packets as specified in the PM-1 PDB packet definitions for S-band telemetry*
  - » Transmit telemetry packets at the intervals defined in the PM-1 PDB packet definition files*

MPS Delta Requirements (Continued)

- Telemetry related (continued)
  - » Provide capability to change the contents of VCDUs, including the Reed-Solomon field
  - » Force telemetry dropouts of one or more VCDUs
  - » Multiplex VCDU-IDs identical to the PM-1 spacecraft on each return link physical channel*
  - » Comply with the telemetry data formats and protocols as specified in EPGS to EDOS interface documents*
  - » Provide option to transmit the contents of a user-provided file containing PM-1 telemetry data*
- PDB related
  - » Employ an offline utility to convert the ASCII-formatted PM-1 PDB files into a binary format useable by MPS*

MPS Delta Requirements (Continued)

The following requirements are unchanged or have only minor wording changes from AM-1 but will result in significant design and code modifications.

- GUI
  - 31110-09 setting of packet generation rates
  - 31200-06 display of command packets
  - 31200-07 display of telemetry packets
- Command
  - 32320-06 command validation
  - 32340-06 setting of telemetry end-item verifiers
  - 32310-01 TGT to EDOS data formats

MPS Delta Requirements (Continued)

- Stored Command Processing
  - 32330-01 execution of stored commands
  - 32340-02/03/04 memory and table load and dump operations
- Telemetry
  - 32120-10 telemetry packet display
  - 32120-16 PM-1 Solid State Recorder (if implemented)
  - 32440-11 storage of housekeeping data for later playback
  - 32410-03/04 transmit telemetry using PM-1 APIDs
  - 32410-05 generation of fill data
  - 32410-08 memory dump simulation
  - 32440-01/04 compliance with telemetry data formats for TGT to EDOS and EPGS to EDOS

MPS Delta Requirements (Continued)

- Timing
  - 32210-03 receipt and use of NASA36 time code
  - 32210-05 spacecraft clock operation
- PDB
  - 33100-01 - 06 translation of the PM-1 PDB

MPS Delta Requirements (Continued)

The following new requirements received from the user community are expected to result in design and/or code changes.

- Flush the GUI log buffer upon user request
- Close the GUI log file upon user request
- Pause/resume Scenario File execution
- Add restrictions to network reconfiguration (stop tlm)
- Display s/c commands by submnemonic
- User supplied PDB-style End-Item Verifier file
- Circular telemetry log file
- Common time source with FOS (NASA36)

Constraints

- MPS simulates one spacecraft on-board computer
- MPS simulates one area of SCC memory

SCTGEN Delta Requirements

- Delta requirements for PM-1
  - Generate convolutionally encoded CADUs
  - Apply randomization to CADU data
  - Support additional time code format (GIIS)
- Enhancements for SCTGEN
  - Upgrade GUI to provide more user control now available only through script
  - Provide internal test tools to support data verification
- Requirements and code changes are minimized due to the generic nature of the SCTGEN utility

System Design Review

- MPS for PM-1
- SCTGEN for PM-1

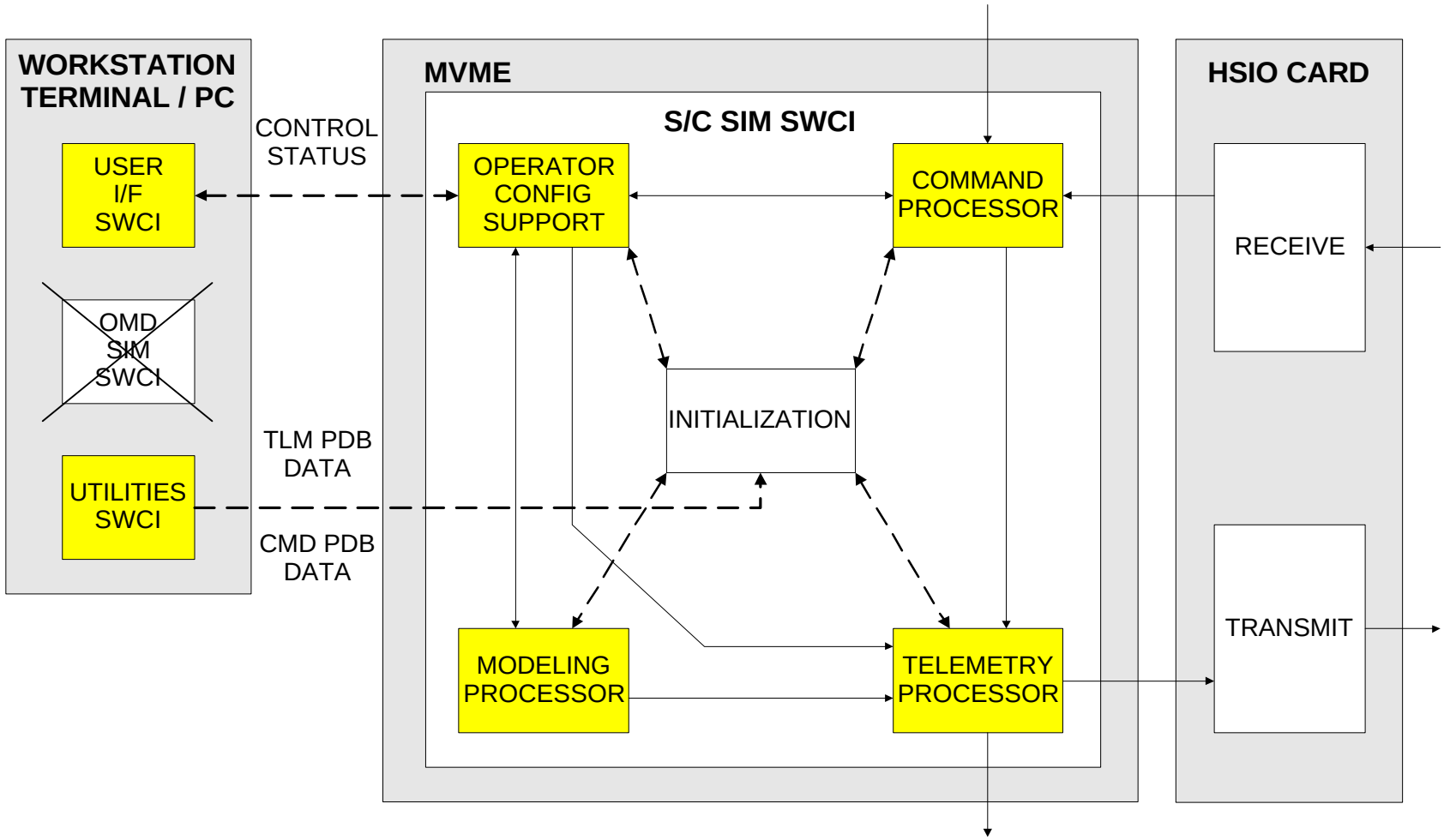
MPS Alternatives

1. Adapt current VME architecture
2. Develop new object-oriented system based on PC architecture
3. Port existing software to a PC-based system
   - Deemed not viable
     - » Code written for the architecture
       - Differences in data type sizes and defaults
       - Byte swapping issue -- VME is “big endian,” PC is “little endian”
       - Differences in operating system calls
       - Tasks become threads
     - » Software would require major redesign and rewrite effort

Alternative 1 - Adapt the Current VME Architecture

- Use the VME hardware “as is”
  - Assumes all components are still available
- Make changes to the software
  - Those required for PM-1
  - Those requested by users to support testing and MPS usage
- Rehost MPS test tool and migrate MPS off-line utilities to a PC

MPS Functional Overview



Changes to Current MPS Design Required for PM-1

- Commands
  - Identification is by APID and VCID vs. Destination and Descriptor command words
  - Command size is much larger
  - Addition of type BD commands
  - Addition of command echo
- Stored Command structures

Changes to Current MPS Design Required for PM-1 (Continued)

- Telemetry
  - CCSDS packets vs major / minor frames
  - 685 possible packet APIDs (vs. 5)
  - Packet contents determined by telemetry format table
  - Packet generation rate is controlled by active packet list
    - » telemetry format table and active packet list can be changed by spacecraft command
  - Fill CADUs can be interspersed with data CADUs

Advantages of VME Architecture

- System is proven
  - Capabilities and limitations are known
- GUI is already developed
- Current staff is experienced with the architecture
- Less software needs to be developed

Disadvantages of VME Architecture

- High unit cost ($ 70 - 100 K)
- High component cost means no spare parts
- Procurement lead time is 3 - 4 months
- Use of operational MPS required for PM-1 development during procurement of new system
- Inefficient development environment
- Poor development tools

Development Issues - Alternative 1

- Development platform will need to be procured and integrated
  - Access to current MPS unit(s) will be required in interim for development for up to 20 hours per week (Monday to Friday, between 8 am to 6 pm, 4 Hrs per day) depending on when process is initiated
  - MPS Network Analysis Tool (NAT) needs to be upgraded for IP interface and rehosted from VME to PC for internal testing

MPS Alternative 2

Alternative 2 - New PC-based Architecture (This is the Prime Alternative)

- Capture the versatility and reliability of the current AM-1 MPS and recreate it on a smaller, more cost effective, PC based platform
- Recreate the current user friendly interface on a cheaper, portable system
- Development will be the result of a combined effort of the ETS team and an experienced simulation development group, which is working as part of a CNMOS initiative to develop the “next generation simulator”

Alternative 2 - New PC based Architecture

- The core functionality of the MPS simulator will be developed through the CNMOS group with the ETS group working in parallel to develop the PM-1 enhancements
- The software will be developed using an Object Oriented methodology in which we will reuse objects created for the PM-1 mission for future missions such as CHEM-1 and ICESAT

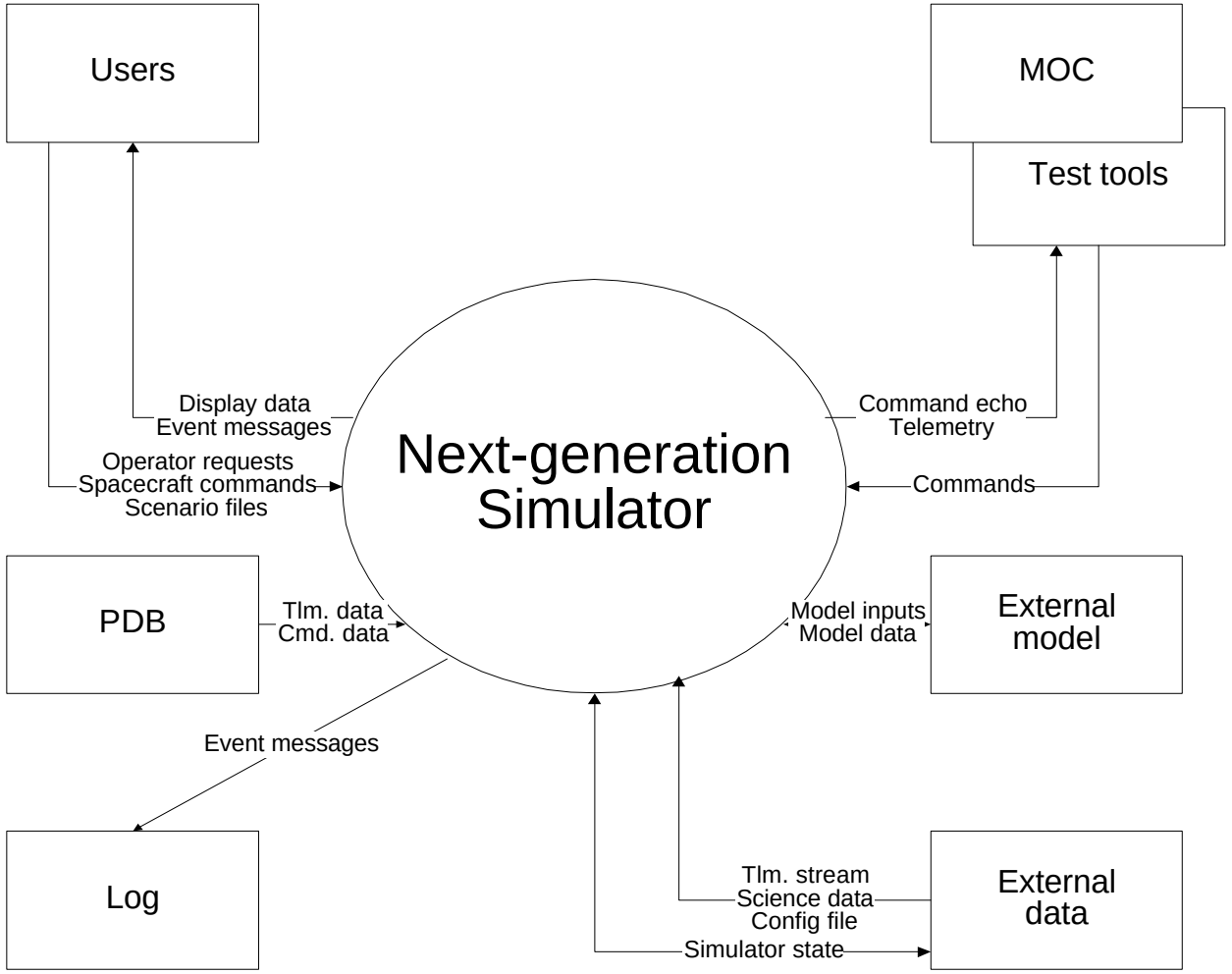
Evolution of New Simulator Concept

- White Paper written to support concept development
- "Next generation simulator" working group established in 3/98
  - Members collectively represent experience building more than 20 spacecraft simulators
- Established hardware and software selection criteria
- Evaluated several alternative architectures and operating systems
  - Candidate architecture selected for prototyping
- Designed major simulator subsystems and classes
- Conducted system requirements review on 8/18/98; design review to be held next month

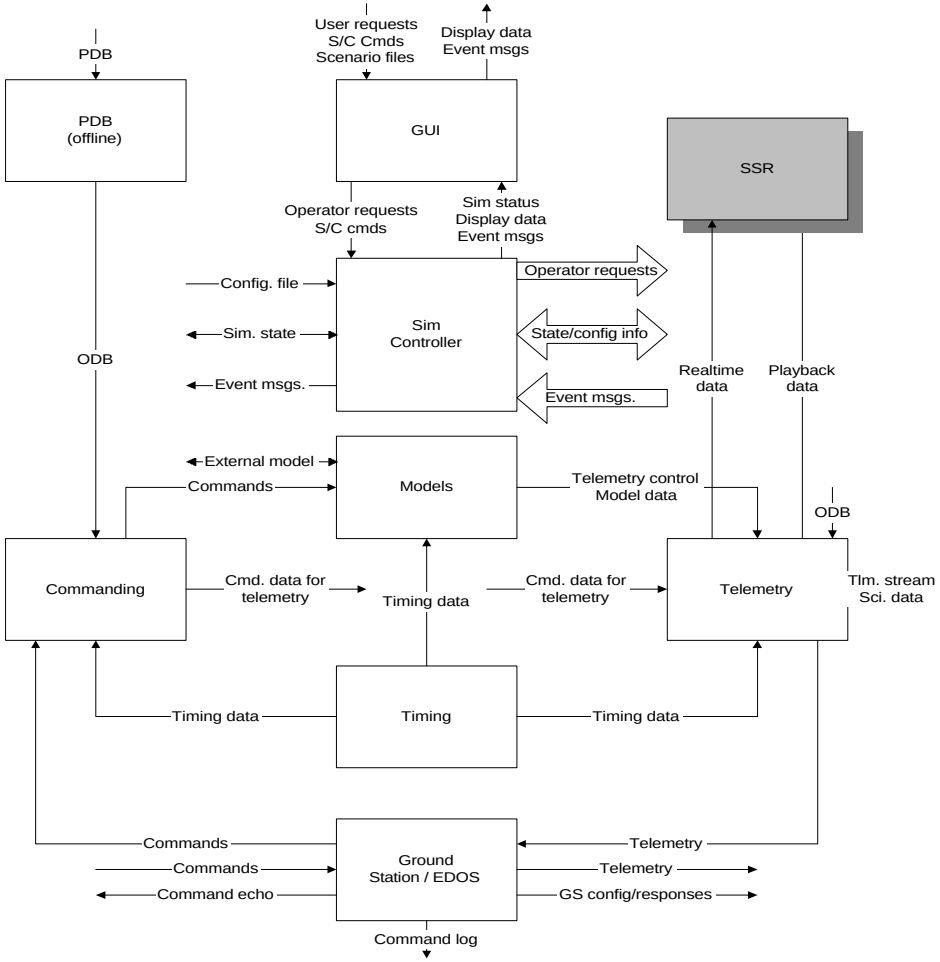
Candidate Architecture

- PC workstation with option of portable version
- Windows NT operating system
- Commercial I/O cards
- Object oriented code design
- JAVA based GUI design

Context Diagram



Level 0 Diagram



Advantages of PC based Architecture

- Standard, more widely supported commercial hardware
- Lower hardware costs
  - Can have more systems at more locations
  - Greater availability of spare parts
- Use of current technology
  - COTS products
  - Development tools
- Expandable with number of peripherals
- Scalable with modules of increasing fidelity

Advantages of PC based Architecture (Continued)

- Easier to operate
- Portable version
- Remote access and control
  - Equipment and user do not have to be colocated
  - Remote support for testing possible
  - Reduce travel cost

Disadvantages of PC-based Architecture

- Approach has risks
  - No complete working model is currently available to build upon
  - Our experience base is working with VMEs and the PDOS operating system
  - Schedule is tight
  - MPS parallel development is dependent on the CNMOS simulator group providing the needed baseline objects

Alternative 2 - Development Approach

- Procure hardware
- Finalize prototype objectives and completion criteria
- Build the proof-of-concept prototype
- Demonstrate prototype
- Make go/no-go decision on PC platform for MPS with concurrence from Mission Systems
- For a no-go decision, revert to the VME adaptation alternative

MPS Windows NT Prototype Plan

- Prototype critical areas:
  - Sustained data rates
  - Real-time performance on Windows NT
  - Java-based remote GUI and GUI interface
- Use AM-1 telemetry and command data formats
- Validate the prototype using EOC and EDOS
- Possibly build upon the portable prototype to support remote ground system or launch site testing if need exists
- Build prototype elements and lessons learned into MPS for PM1

MPS Software Estimates

	MPS VME Adaptation		New PC Architecture	
	Existing (DSI)	New for PM-1 (DSI)	Core System * (DSI)	New for PM-1 (DSI)
Initialization	5600	0	0	0
Sim Controller (Includes Initialization, GUI, Timing, Network)	0	0	22500	0
User Interface Support	1600	2000	0	0
Command	4150	2000	2000	11500
Telemetry	8550	2600	2000	12500
Modeling	1500	0	1000	3000
SSR		4500	1000	6000
Timing	2200	2000	0	0
Network	2500	0	0	0
Utilities/PDB	5300	4500	0	1500
GUI	22900	3000	0	0
Total DSI	54300	20600	28500*	34500

* Software provided as part of the simulator being developed under the CNMOS process improvement initiative

Recommended Alternative
New PC-based Architecture

- MPS/PM-1 will be implemented to run on a PC platform running Windows NT
  - » Contemporary software design process
  - » Contemporary hardware
  - » COTS-based
  - » Low replication costs
  - » Scalable for future missions
  - » Portable

Recommendation (Continued)

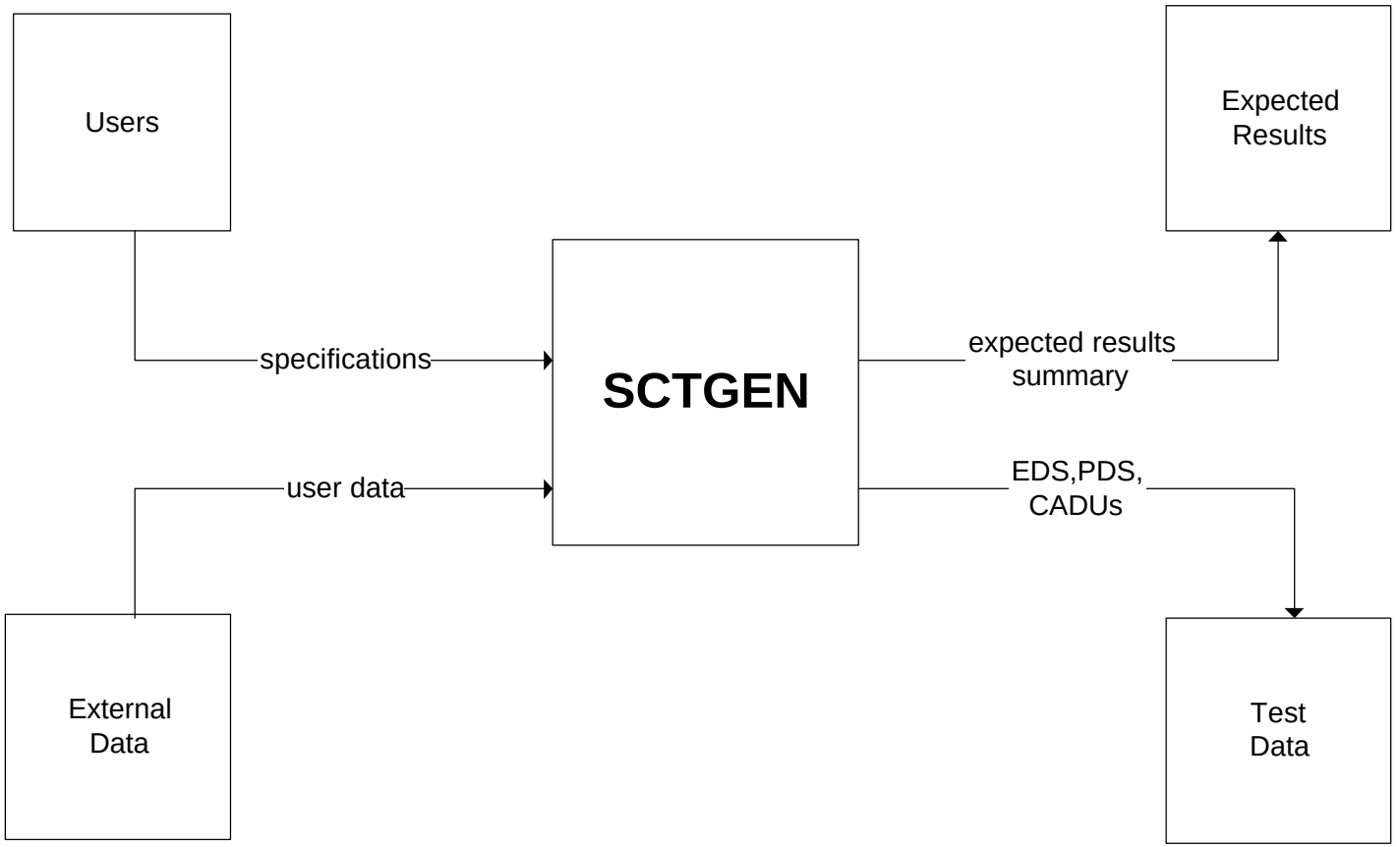
- ETS team will build upon baseline system being developed as a CNMOS process improvement initiative
  - Core objects being developed by CNMOS “next-generation simulator” group
  - PM-1 extensions being developed by ETS team
  - Effort being performed in parallel

Risk Mitigation

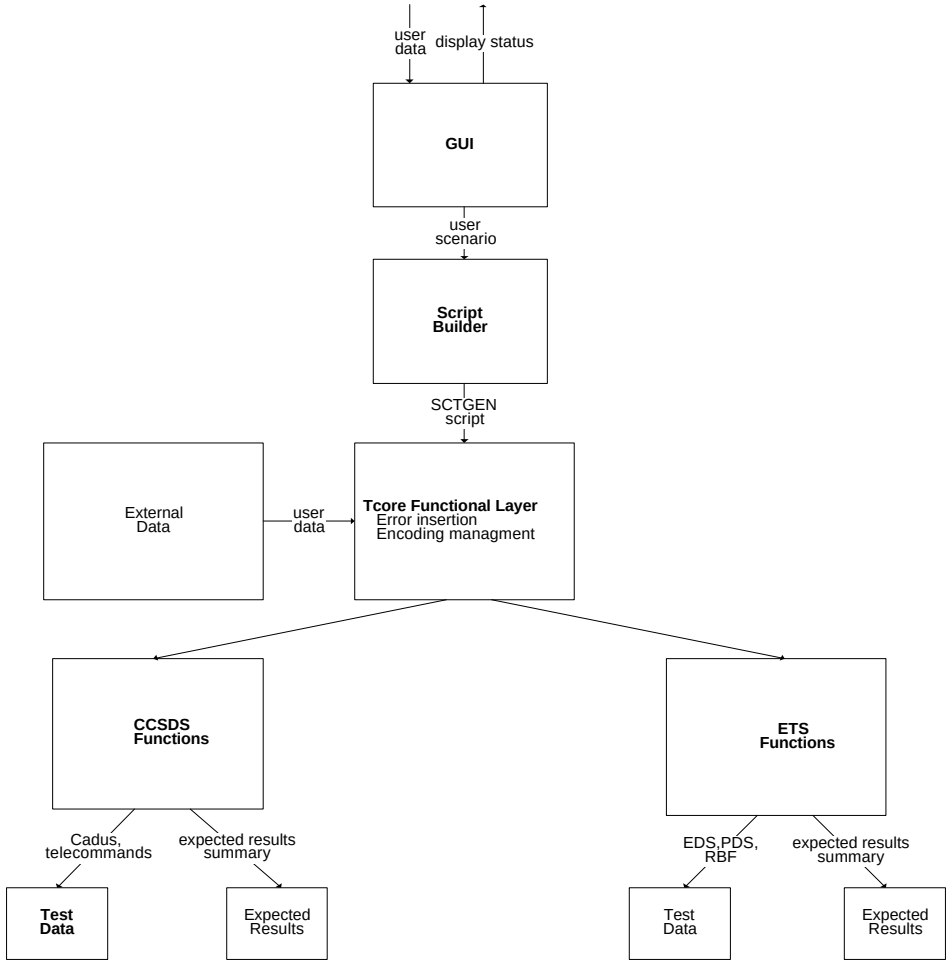
- Build and demonstrate proof of concept prototype in three months
- Participate as a team member of the development group for the “next generation simulator” core baseline system
- Acquire a third MPS VME system to have available to support remaining AM-1 testing and to be ready for PM-1 development if necessary

SCTGEN Design

SCTGEN Context Diagram



SCTGEN Level 0 Diagram



SCTGEN Development Approach

- Modify existing software system for PM-1
  - Separate version of SCTGEN not needed as is case for MPS
- Make required PM-1 changes
  - Randomization of CADUs
  - Convolutional encoding of CADUs
  - GIIS time code format for simulated instrument CADU data
  - User interface control of PM-1 changes
- Provide limited enhancements
  - Provide more user control from GUI
  - Create test tools for data validation of changes

SCTGEN Software Estimates

	Current System (DSI)	New for PM-1 (DSI)
Changes for PM-1		4,500
Enhancements		500
Total DSI	30,000	5,000

SCTGEN Development Issues

- ETS HP development system not Y2K compliant
  - Installation of Y2K-compliant operating system could impact other supported applications
- Lack of SGI and Sun test platforms
  - Require access to SUN and SGI computers to create and test executable versions required for delivery
  - Require up to 4 hours per day during standard working hours when system undergoing testing

Concluding Material

Test Approach

- Combined testing approach used for ETS/AM-1 will be applied for ETS/PM-1
  - Existing test plans and procedures will be updated for MPS/PM-1 and SCTGEN/PM-1
  - Tester familiarization with systems begun early during development
  - Test reports prepared after execution of tests
    - » Quick look reports generated on daily or as needed basis during combined testing
    - » Final test status summary reports prepared on each release
  - Discrepancy Report Tracking Tool (DRTT) used for both IDRs and DRs
- Early user access to engineering version proved highly beneficial

Proposed Schedule

ETS Milestones

<u>AM-1 Maintenance</u>		
MPS Release 1.6	11/98	
<u>PM-1 Development</u>		
Prototype Demonstration	1/99	
Detailed design and release plan working group	1/99	
Release 2.0	6/99	L-18 months
Release 2.1 (All requirements met)	12/99	L-12 months
Release 2.2 (Maintenance and upgrade)	4/00	
Release 2.3 (Maintenance and upgrade)	8/00	
<u>SCTGEN Development</u>		
Release 2.0	4/99	
Release 2.1	9/99	

MPS Release 2.0 Capabilities

Subsystem	**MPS VME Adaptation Alternative**	**New PC Alternative**
Telemetry	Static data Multiple rates Serial and IP modes	Static data Multiple rates Serial and IP modes
Commanding	Command ingest Update command counters Update CLCW	Command ingest Update command counters Update CLCW
PDB Translator	Command side PDB translation	Command side PDB translation
User Interface	Completed	Functionality to support the release Display CADUs, packets Display telemetry status Display event messages
Modeling	No activity	No activity
Time	Maintain spacecraft time Maintain GMT	Maintain spacecraft time Maintain GMT

MPS Release 2.1 Capabilities

Subsystem	**MPS VME Adaptation Alternative**	**New PC Alternative**
Telemetry	Complete Support CCSDS formats Update telemetry points Set values in headers and trailers	Complete Support CCSDS formats Update telemetry points Set values in headers and trailers
Commanding	Complete Update end item verifiers Process stored commands Support memory loads and dumps Support command echo	Complete Update end item verifiers Process stored commands Support memory loads and dumps Support command echo
PDB Translator	Complete Telemetry side PDB translation Modeling side PDB translation	Complete Telemetry side PDB translation Modeling side PDB translation
User Interface	No activity	Complete
Modeling	Complete	Complete
Time	No activity	No activity

Needs List and Need Dates

Decision on VME or PC based MPS architecture	10/1/98
Go/no-go decision if prototype approved	1/99
Details of Scenario File generation for MPS	12/98
Determination of need for or extent of SSR simulation, along with SSR implementation details for MPS	12/98
Arrangement for access to upgraded OS for HP and access to SGI and Sun platforms for testing for SCTGEN	1/99
PDB format for PM-1 for MPS	1/99
Copy of PM-1 PDB for MPS	2/99
Stored command processing details for MPS	5/99
Memory load and dump details	5/99
Command echo details	5/99

Request for Information

- Request for additional information or clarification should be sent to Mr. Willie Fuller, wfuller@pop500.gsfc.nasa.gov, by October 2, 1998

Information Sources

- ICD Between the EOS Common Spacecraft and the EOS Ground System (EGS) April 29, 1997 (TRW)
- EOS Command and Telemetry Handbook for the PM-1 Spacecraft, May 15, 1998 (TRW)
- ICD Between the EDOS and EGS Elements, August 9, 1996, through latest DCN (TRW)
- EOS PM-1 Mission Operations Concept Paper, Preliminary, Revision E, October 29, 1997 (Omitron, Inc.)
- EOS Spacecraft Operations Requirements Document (SORD), April 8, 1997 (TRW)
- Project Data Book (PRDB), March 27, 1998 (TRW)

Acronyms

AM-1	Morning equatorial crossing spacecraft series
APID	Application Identifier
CADU	Channel Access Data Unit
CCSDS	Consultative Committee on Space Data Systems
CERES	Clouds and the Earth's Radiant Energy System
CLCW	Command Link Control Word
CLTU	Command Link Transmission Unit
COTS	Commercial, off-the-shelf
CPU	Central Processing Unit
CSC	Computer Science Corporation
CSOC	Consolidated Space Operation Contract
DRB	Discrepancy Review Board
DRTT	Discrepancy Report Tracking Tool
DSI	Delivered Source Instructions
ECS	EOS Core System
ECT	EOS Compatibility Tests
EDOS	EOS Data and Operations System
EDS	Expedited Data Set
EDU	EDOS Data Unit
EGS	EOS Ground System
EOC	EOS Operations Center
EOSDIS	Earth Observing System Data and Information Systems
EPGS	EOS Polar Ground Stations
ETS	EOSDIS Test System
F&PR	Functional and Performance Requirements
FOS	Flight Operations Segment
FOT	Flight Operation Team
FTP	File Transfer Protocol
GMT	Greenwich Mean Time
GUI	Graphical User Interface
HP	Hewlett Packer
HSIO	High Speed Input Output
ICD	Interface Control Document
MPS	Multimode Portable Simulator
MVME	Motorola VME
NAT	Network Analysis Tool
OMD	Operations Management Data
OMDSIM	OMD Simulator
PC	Personal Computer
PDB	Project Database
PDS	Production Data Set
PM-1	Afternoon equatorial crossing spacecraft series

Acronyms (Continued)

PDB	Project Data Book
RBF	Rate Buffer File
SCC	Spacecraft Controller
SCTGEN	Simulated CCSDS Telemetry Generator
SGI	Silicon Graphic
SI&T	System Integration and Test
SORD	Spacecraft Operations Requirements Document
SSIM	Spacecraft Simulator
SUN	Sun Microsystems
SWCI	Software Configuration Item
TGT	TDRSS Ground Terminal
VCDU	Virtual Channel Data Unit
VME	VersaModule Eurocard
Y2K	Year 2000 compliance